The Unintended Consequences of Property Tax Relief: New York's STAR Program

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Abstract

New York's School Tax Relief Program, STAR, provides state-funded property tax relief for homeowners. Like a matching grant, STAR changes the price of public services, thereby altering the incentives of voters and school officials and leading to unintended consequences. Using data for New York State school districts before and after STAR was implemented, we find that STAR resulted in small decreases in student performance along with significant decreases in the efficiency with which this performance is delivered and significant increases in school spending and property tax rates. These tax-rate increases magnify existing inequities in New York State's education finance system.

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Introduction

Thanks to a relatively low state share of funding for education and a wide range in property values per pupil, New York State has long faced the dual problem of high property tax rates and severe funding disparities across school districts. In 1997, New York State enacted a state-funded homestead exemption, the School Tax Relief Program or STAR, to provide property tax relief for homeowners. Although it was not recognized in the policy debates at the time STAR was passed, the use of state tax sources to lower the school property tax burden on homeowners significantly alters the way public schools are financed and magnifies the funding disparities. Moreover, the design of STAR has resulted in unintended consequences for student performance, school spending, school district efficiency, and local property tax rates. This impact on school finance and these unintended consequences are the subjects of this paper.

These issues were first raised by Duncombe and Yinger (1998a, 2001). Building on the equivalence theorems of Bradford and Oates (Oates, 1972; Bradford and Oates, 1971a, 1971b), they argued that the STAR homestead exemption was equivalent to a form of matching aid. Like matching aid, STAR lowers voters' tax prices and therefore is likely to increase the demand for education and lead to higher property tax rates, higher education spending, and higher student performance. Duncombe and Yinger also argued that the STAR-induced decline in tax price lowers voters' incentives to monitor school officials and therefore may result in less efficient school districts. In this paper we estimate the impact of STAR on student performance, school district expenditures, school district efficiency, and school property tax rates.

Many studies find that tax prices have a significant impact on the demand for local services.[1] Fisher (1988), Addonizio (1990, 1991), and Rockoff (2003), explore the impact of property tax relief programs on school spending. The first two of these studies examine a circuit-breaker implemented in Michigan in the 1970s that altered tax prices. Both studies find evidence that these tax-price changes had a significant impact on public spending. Rockoff (2003) examines STAR. He finds that replacing 10 percent of school property taxes with STAR funds would raise school spending by 1.6 percent.[2]

These studies all estimate the elasticity of expenditure per pupil with respect to tax price. This approach has the practical advantage that it does not require a measure of the final output (in the sense of Bradford, Malt, and Oates, 1969) of education, such as student test scores. It also has a major disadvantage, however; it cannot determine whether the impact of tax-price on spending reflects changes in demand or changes in school district efficiency.

In contrast to the previous literature, this study estimates a demand model with a final output as the dependent variable and explicitly considers economies of scale and school district efficiency. We estimate the direct impact of STAR on the demand for education and the indirect impact that arises because STAR affects efficiency and efficiency affects demand.

The Structure of STAR and the Distribution of STAR Benefits

The STAR program provides partial exemptions from school property taxes for owner-occupied primary residences.[3] The basic STAR exemption is available to all taxpayers who own their primary residence in New York State, regardless of age or income, including owners of one-, two-, and three-family houses, condominiums, cooperative apartments, mobile homes, or residential dwellings that are part of mixed-use property.[4] An enhanced STAR exemption is available only for homeowners age 65 or above who have annual incomes no greater than $60,000.[5] Renters receive no exemption.

The basic exemptions were $10,000 in 1999-2000, $20,000 in 2000-2001, and $30,000 in 2001-2002 and thereafter,[6] whereas the enhanced exemption was set at $50,000 for the 1998-

1999 school year and remained at that value throughout the sample period of this study. In 2006, however, elected official in New York increased the STAR exemptions by another 30 percent. All STAR exemptions are subject to two adjustments. First, they are all adjusted to be consistent with the assessment/sales ratio in each assessing unit. Second, they are adjusted upward by a "sales price differential factor" in counties in which the median residential sales price exceeds the statewide median sales price.[7]

Although New York has several other property tax exemption programs, STAR is unique in two ways (New York State Office of Real Property Services (ORPS), 2004). First, it is the only exemption funded by the state. All other exemptions erode the local tax property base and shift the burden of the tax toward property owners not eligible for the exemptions. Second, STAR is unique in terms of its scope and the size of the exemption. Although some other exemption programs have applied to a significant number of taxpayers, including 650,000 veterans and 180,000 senior citizens, none of them has come close to the breadth of the STAR program, which applies to roughly 3 million taxpayers. These features also stand out at the national level. Most states have some form of property tax exemption, but only a few other states, including Indiana, Iowa, and Massachusetts, have general property tax exemptions with state reimbursement (Duncombe and Yinger, 2001).

As shown in Table 1, STAR provided property tax relief per pupil in 2001-2002 ranging from $320 in New York City to $1,395 in the downstate suburbs. Because of their high renter populations, all the large cities except Yonkers receive relatively little benefit from STAR. Table 1 also indicates that the STAR exemptions ranged from 3.61 percent of property value in NYC to 15.91 percent in Yonkers.

Conceptual Foundations

A voter's tax price reflects the interplay between the voter's budget constraint and the government budget constraint. In this section we derive an expanded tax price that reflects both STAR and school district efficiency and incorporate this tax price into demand and cost/efficiency models. We show that STAR has direct impacts on the demand for school quality and indirect impacts on demand that arise because STAR also affects efficiency.

The Demand for School Quality

Let V stand for the market value of a voter's home and t indicate the effective property tax rate. Without STAR, the property tax payment would be tV. STAR exempts the first X dollars of market value from tax, so the property tax payment with STAR is $t(V\text{-}X)$. As noted earlier, the value of X in our sample period was \$30,000 in most districts, but was sometimes adjusted upward for high sales prices.[8] If Y is a voter's income and Z is spending on everything except school property taxes, then a voter's budget constraint with STAR is

$$Y = Z + t(V - X) \tag{1}$$

The school district faces a cost function, $C\{S\}$, where C is total cost per pupil and S is school quality as measured by student performance on certain tests. The derivative of this function, $\partial C/\partial S$, equals marginal cost, MC. Spending per pupil, E, equals $C\{S\}$ divided by district efficiency, e. This efficiency measure is scaled to equal 1.0 in a fully efficient district, that is, in a district that makes full use of the best available technology, and to fall below one in less efficient districts. Hence, this formulation indicates that inefficient districts spend more than the amount indicated by $C\{S\}$ to obtain a given level of S. Revenue comes from property taxes and lump-sum state aid. Because the state fully compensates a district for its STAR exemptions, these exemptions have no impact on the district budget constraint. Let $\bar{V}$ indicate property value per pupil and A indicate state aid per pupil. Then the district budget constraint is

$$E \equiv \frac{C\{S\}}{e} = t\bar{V} + A \tag{2}$$

Solving equation (2) for t and substituting the result into equation (1) yields.

$$Y + A\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) = Z + \frac{C\{S\}}{e}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) \tag{3}$$

Tax price, *TP*, is what an increment in *S* costs a voter, so it can be derived by differentiating a voter's spending, the right side of equation (3), by *S*:

$$TP \equiv \frac{\partial \text{Spending}}{\partial S} = \frac{dC}{dS} e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) = \left(MC\right) e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) \tag{4}$$

The direct impact of STAR appears in the last term of equation (4); an exemption, *X*, is equivalent to a matching aid program with a matching rate $m = X/V$. This matching rate varies across districts and across time both because of the phase in and the sales price differential factor in STAR and because of variation in *V*. Throughout this paper, we refer to *X/V* as the implicit STAR matching rate and to (1- *X/V*) as the STAR component of tax price.

In a standard median-voter model, the demand for school quality, *S*, is a function of median income, as augmented by state aid, and of median tax price. Interpreting equation (1) as the median voter's budget constraint; using a standard multiplicative form for demand; adding a flypaper effect, *f*; and placing other demand determinants in a constant, *K*, we find that[9]

$$S = K\left(Y + fA\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\theta}\left(\left(MC\right)e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\mu} \tag{5}$$

where θ is the income elasticity of demand, μ is the (negative) price elasticity of demand. Our principal hypothesis is that the STAR term, $(1 - X/V)$, has a negative coefficient.

Tax price in equation (5) has four components: marginal cost, (the inverse of) efficiency, tax share, and STAR. These components all enter tax price in the same way but may have different elasticities in practice. Voters may be more aware of, and hence more responsive to, the STAR component than to the tax-share component, for example, because they must apply for the STAR rebate. Thus, we estimate all four elasticities and use them in our simulations; to simplify the presentation, however, we use a single elasticity in the text.

Equation (5) also reveals that STAR affects the value of aid to voters. In the standard model, the value to a voter of state aid depends on the voter's tax share, that is, on the voter's share of the money saved by cutting local taxes (Oates, 1972). This effect explains why tax share appears in the augmented income term. Equation (5) shows that STAR exemptions also lower a voter's valuation of aid. We later test for this effect, which is discussed in Duncombe and Yinger (1998a, 2001) and Rockoff (2003).

The Determinants of School Efficiency and Educational Cost

Although e in equation (5) cannot be measured directly, it may depend on both income augmented by aid and on tax price. This insight leads to a method for estimating e and for determining STAR's indirect impact on demand, which operates through efficiency.

As pointed out by Duncombe, Miner, and Ruggiero (1997) and Duncombe and Yinger (1997, 1998b) income may affect efficiency in two ways. First, a higher income may weaken voters' incentives to monitor school officials. Second, a higher income may encourage voters to push for a broader set of objectives. Because efficiency must be defined relative to spending on a particular objective, such as student performance on certain tests, spending to promote other objectives is inefficient. Given this role of voter demand and monitoring, we use the same definition of income in the efficiency equation as in the demand equation.

These studies also provide evidence that a tax-price decrease, like an income increase, weakens voters' incentives to monitor school officials and boosts their demand for a broad set of objectives. Thus, tax price also belongs in the efficiency equation. As in the case of income, the role of voter behavior in this analysis indicates that the tax-price term in the efficiency equation, like the one in the demand equation, should reflect tax share, marginal cost, and STAR.[10]

Our approach is to incorporate these hypotheses into a multiplicative efficiency equation. For expositional purposes (but not in our estimations), we assume that the flypaper effect is the same in the efficiency equation as in the demand equation. Determinants of efficiency other than augmented income and tax-price, which are discussed below, are represented by *M*. This approach leads to the following efficiency equation, where γ is the income elasticity of efficiency, δ is the price elasticity of efficiency, and k is a constant:

$$e = k\, M^{\rho} \left(Y + f A \left(\frac{V}{\bar{\bar{V}}} \right) \left(1 - \frac{X}{V} \right) \right)^{\gamma} \left(\left(MC \right) \left(\frac{V}{\bar{\bar{V}}} \right) \left(1 - \frac{X}{V} \right) \right)^{\delta} \tag{6}$$

Based on the literature, we expect that a higher augmented income leads to less efficiency ($\gamma < 0$) and that a higher tax price leads to more efficiency ($\delta > 0$).

Efficiency cannot be measured directly, but its determinants can be incorporated into the estimation of a cost function (Duncombe and Yinger, 2001). Following standard practice (Downes and Pogue, 1994; Duncombe and Yinger, 1997, 1998b, 2000; Reschovsky and Imazeki, 1998, 2001, 2003), we assume that educational cost depends, in a multiplicative way, on teacher salaries, *W*, student enrollment, *N*, and pupil characteristics, *P*. Unlike previous studies, however, we identify returns to quality scale (as defined in Duncombe and Yinger, 1993). In symbols,

$$C\{S\} = \kappa S^{\sigma} W^{\alpha} N^{\beta} P^{\lambda} \tag{7}$$

where κ is a constant and σ measures returns to quality scale; $\sigma < 1.0$ indicates increasing returns and $\sigma > 1$ indicates decreasing returns. With this cost function, marginal cost is not constant:

$$MC \equiv \frac{\partial C\{S\}}{\partial S} = \sigma \kappa S^{\sigma-1} W^{\alpha} N^{\beta} P^{\lambda} \tag{8}$$

Substituting equations (6)-(8) into the definition of E in equation (2), we find that

$$E = k^{*}\left(S^{\sigma-\delta(\sigma-1)}\right)\left(W^{\alpha} N^{\beta} P^{\lambda}\right)^{1-\delta}\left(M^{-\rho}\left(Y + fA\left(\frac{V}{\overline{\overline{V}}}\right)\left(1-\frac{X}{V}\right)\right)^{-\gamma}\left(\left(\frac{V}{\overline{\overline{V}}}\right)\left(1-\frac{X}{V}\right)\right)^{-\delta}\right) \tag{9}$$

where k^{*} combines the constants in equations (6)-(8). Taking logs and, for augmented income, using the simplification that $\ln\{1+\alpha\} \approx \alpha$ when α is less than one, yields our estimating equation:

$$\begin{aligned} \ln(E) = {} & \ln(k^{*}) + (\sigma - \delta(\sigma-1))\ln(S) + \alpha(1-\delta)\ln(W) + \beta(1-\delta)\ln(N) + \lambda(1-\delta)\ln(P) \\ & - \rho\ln(M) - \gamma\ln(Y) - \gamma f\left[\left(\frac{A}{Y}\right)\left(\frac{V}{\overline{\overline{V}}}\right)\left(1-\frac{X}{V}\right)\right] - \delta\ln\left(\frac{V}{\overline{\overline{V}}}\right) - \delta\ln\left(1-\frac{X}{V}\right) \end{aligned} \tag{10}$$

This equation identifies all the parameters in equations (6) and (7) except the constant terms, which are not needed to calculate cost and efficiency indexes. The efficiency price elasticity, δ, equals minus one multiplied by the coefficient of the tax-share variable. Once δ is known, the values of the cost parameters, α, β, and λ, can be determined from the coefficients of the cost variables. Since δ is expected to be positive, omitting this correction is likely to result in an *understatement* of the impact of wages, enrollment, and student characteristics on educational costs. The efficiency income elasticity, γ, is the negative of the coefficient of ln(Y), and the flypaper effect, f, is the coefficient of the aid variable divided by -γ. The economies-of-scale parameter, σ, can be found using the coefficient of ln(S) and the estimate of δ.

The three components of tax-price in equation (6) may not have the same elasticities. We can estimate separate elasticities for the last two terms, but not for the first, which appears in all the coefficients in the first line of (10). We assume that the elasticity of e with respect to MC equals the estimated elasticity of e with respect to $V/\overline{V}$.[11]

Other approaches to estimating efficiency have appeared in the literature. An approach developed by Ray (1991), McCarty and Yaisawarng (1993), and Duncombe and Yinger (1997, 1998b) involves two steps.[12] The first step is to estimate the minimum spending frontier for any combination of student outcomes using Data Envelopment Analysis (DEA).[13] DEA produces an index that captures variation across districts in both efficiency and educational costs. The second step is to regress the DEA index on cost variables and on variables thought to influence efficiency. The coefficients of this regression can then be used to remove the impact of the cost variables from the DEA index, leaving a measure of efficiency. DEA is designed to identify production frontiers with multiple outputs, but is not necessary or appropriate with a single output, as in the case of our education-performance index.[14]

Implications of the Link between Demand and Efficiency

Once equation (10) has been estimated, two approaches are available for estimating the demand equation (5), and hence for determining the indirect impact of STAR on demand through efficiency. The first approach is to use the estimated parameters from (10), along with equations (6) and (8), to calculate indexes of MC and e for every district. The problem with this approach is that both MC and e (through MC) are functions of S, so that these two variables are endogenous by definition. Moreover, it may be impossible to find instruments for addressing this endogeneity because variables correlated with the impact of scale economies in MC and e, which operate through S, are, by definition, correlated with the dependent variable, namely, S.

The second approach is to exploit the multiplicative form of these equations to solve for *S*, that is, to eliminate *S* from the right side of the demand equation. This approach complicates the interpretation of the estimated parameters in the demand equation, but it eliminates the troublesome type of endogeneity just described. The first step in this approach is to calculate partial indexes for the components of cost and efficiency that do not involve *S*:

$$C^* = \sigma\kappa^* W^\alpha N^\beta P^\lambda \tag{11}$$

and

$$e^* = k^{**} M^\rho \left(Y + fA\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right)\right)^\gamma \left(C^*\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right)\right)^\delta \tag{12}$$

where κ^* is defined so that C^* equals 1.0 in the average district and k^{**} is defined so that e^* equals 1.0 in the most efficient district. This scaling alters the constant term in our demand regression, but does not alter any other estimated coefficient. When estimated, equation (10) includes an error term. As discussed below, C^* can only be identified through its links to factors outside the control of school officials, namely, *W*, *N*, and *P*. Thus, we assume that this error term reflects unobserved components of efficiency, not cost, and we include it in our efficiency index.

Now substituting equations (6) and (8) into equation (5) and making use of equations (11) and (12), we can write the demand function as:

$$S = K^* \left(Y + fA\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right)\right)^{\theta *} \left(\left(C^*\right)\left(e^*\right)^{-1}\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right)\right)^{\mu *} \tag{13}$$

where

$$\theta^* = \frac{\theta}{1-\mu(\sigma-1)(1-\delta)} \tag{14}$$

and

$$\mu^* = \frac{\mu}{1-\mu(\sigma-1)(1-\delta)} \tag{15}$$

Equation (13) can be estimated by taking logs and using the approximation for the aid term derived earlier. The values of σ and δ come from the estimation of equation (10). Equation (15) can be used to find μ based on the coefficient of the tax-share term in equation (13). Equation (14) can then be used to find θ based on the coefficient of the income term in equation (13), which leads, in turn to a value for f based on the coefficient of the aid term. Note that $\theta = \theta^*$ and $\mu = \mu^*$ when there are constant returns to quality scale ($\sigma = 1$).

Because e^* depends on augmented income and tax-price, substituting equation (12) into equation (13) yields another form for the demand function, namely,

$$S = K^{**} M^{-\rho\mu^*} \left(Y + fA\left(\frac{V}{\overline{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\theta^* - \gamma\mu^*} \left((C^*)\left(\frac{V}{\overline{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\mu^*(1-\delta)} \quad (16)$$

Equation (16) has two important implications. First, when efficiency is omitted from the demand equation, the estimated "income" elasticity is ($\theta^* - \gamma\mu^*$) and the estimated "price" elasticity is $\mu^*(1 - \delta)$, which are smaller (in absolute value) than θ and μ, respectively (or than θ^* and μ^*).

The same issues arise when e is omitted from an expenditure form of the demand equation, which is equation (16) multiplied by MC/e with the assumption of constant returns to scale ($\sigma = 1$). This approach is used by Rockoff (2003). In this case, the coefficient of the income term is $[\theta - \gamma(\mu+1)]$ and the coefficient of the tax-price term is $[\mu - \delta(\mu+1)]$.[15] Even if the assumption of constant returns is correct, the estimated coefficients cannot be interpreted as income and price elasticities of demand unless γ and δ are assumed to be zero. Including district fixed effects and regional time trends to account for efficiency, the Rockoff (2003) strategy, does not eliminate the extra terms in these coefficients because e is directly affected by STAR and varies over time in each district.

The Rockoff approach provides a demand interpretation for an expenditure equation that is quite different from the cost/efficiency interpretation we give to equation (9). Nevertheless, these two interpretations are not inconsistent. Under the demand interpretation, an expenditure equation explores the demand for a broad but unspecified set of educational outcomes, whereas we explore cost and efficiency in providing a specific school performance index. A finding that the demand for a broad set of education outcomes increases with district income or decreases with district tax price implies that an income increase or a tax-price decrease encourages a district to provide a broader set of educational outcomes, which is equivalent to becoming more inefficient in delivering the performance index in our analysis. Overall, both interpretations are legitimate, but the cost interpretation has the great advantage that it does not require the assumptions that σ equals 1 and that γ and δ equal zero.[16]

The second implication of equation (16) is that, even with constant returns, the impact of STAR on the demand for S has two direct components, a price effect and a change in the value of A, and two indirect components, which operate through efficiency. By lowering tax price, STAR gives a direct boost to demand, but it also lowers efficiency, which indirectly results in lower demand. The net impact of these two responses is summarized by the $\mu(1 - \delta)$ exponent. The (negative) price elasticity, μ, indicates the direct effect; it is offset to some degree by the product of δ, which is positive, and μ. In addition, by lowering the value of aid to a voter, STAR lowers demand, but this drop in augmented income also leads to higher efficiency, which indirectly boosts demand. The net impact of these two responses is summarized by the $(\theta - \gamma\mu)$ exponent. The positive income elasticity, θ, is offset, at least in part, by the product of γ (negative) and μ.

The simulations in a later section incorporate the exact form of these indirect effects, but it is instructive at this point to examine them using calculus approximations. With constant returns, differentiating equation (16) respect to $m = X/V$ reveals that the impact of STAR on S is[17]

$$d\ln\{S\} = -\left(\frac{(\theta-\gamma\mu) f A\left(\frac{V}{\overline{V}}\right)}{Y + f A\left(\frac{V}{\overline{V}}\right)} + \mu(1-\delta)\right)\left(\frac{X}{V}\right) \tag{17}$$

The first term in equation (17) is the net income effect and the second term is the net price effect. The second term shows that the direct positive price impact of STAR on *S*, -μ, is offset to some degree by the indirect effect, $\mu\delta$, that arises because STAR has a price impact on efficiency, which in turn affects *S*. Without constant returns, θ and μ in equation (17) must be replaced by θ^* and μ^* as defined by equations (14) and (15).

Using the expenditure form of the demand equation, again with constant returns, we can also derive the impact of STAR on *E*:

$$d\ln\{E\} = -\left(\frac{\left(\theta-\gamma(\mu+1)\right) f A\left(\frac{V}{\overline{V}}\right)}{Y + f A\left(\frac{V}{\overline{V}}\right)} + \mu - \delta(1+\mu)\right)\left(\frac{X}{V}\right) \tag{18}$$

In this case, the elasticity expressions in the numerators summarize the direct impacts of STAR on efficiency and the direct and indirect impacts of STAR on S and hence on C.[18]

The district budget constraint, equation (2), implies that

$$dt = \left(\frac{d\ln\{E\}}{\frac{X}{V}}\frac{E}{\overline{V}}\right)\left(\frac{X}{V}\right) = d\ln\{E\}\left(\frac{E}{\overline{V}}\right) \tag{19}$$

Not surprisingly, the impact of STAR on property taxes has the same sign as its impact on spending, regardless of scale economies. Finally, we can differentiate (6) to determine the impact of STAR on school district efficiency. The result with $\sigma = 1$ is:[19]

$$d\ln\{e\} = -\left(\frac{\gamma f A\left(\frac{V}{\overline{\overline{V}}}\right)}{Y + fA\left(\frac{V}{\overline{\overline{V}}}\right)} + \delta\right)\left(\frac{X}{V}\right) \tag{20}$$

STAR raises efficiency by cutting the value of aid to voters (the first term) but also lowers efficiency by lowering voters' tax prices (the second term). Without constant returns, the coefficient in the numerator of the first term becomes [$\gamma + \theta^*(\sigma$-1)δ] and the coefficient in the numerator of the second term becomes [$\delta + \mu^*(\sigma$-1)δ]. The increase in S caused by STAR raises the marginal cost of S, thereby boosting efficiency and offsetting, at least in part, the drop in efficiency associated with the STAR implicit matching rate.

Data, Empirical Strategy, and Results

Our conceptual framework calls for the estimation of two equations: the cost/efficiency equation (10) and the demand equation (13). In this section we describe our data and present our strategy for estimating each of these equations. To take advantage of the natural experiment generated by STAR, we estimate these equations using data from years before and after the implementation of the basic STAR exemption.

Data

Our data come from ORPS, the New York State Comptroller, the U.S. Census, and the New York State Education Department (SED). Every two years ORPS conducts a survey to examine the relationship between assessed and market value in each assessing unit. The survey results are used to estimate an assessment ratio, also called the equalization rate, by property type for each assessing unit. As indicated earlier, this equalization rate is used to adjust the STAR exemption amounts whenever property is not assessed at full value. In addition, ORPS collects a parcel-level assessment data set that contains information on assessment, location, and property type information for all the parcels in New York State. The decennial Census provides information on median house value in each school district, based on owners' estimates.

The two property value variables are the tax share, $V / \bar{V}$, and the implicit STAR matching rate, X/V, where V is median house value and $\bar{V}$ is total property value per pupil. Total taxable property value is total assessed value minus all property tax exemptions, except STAR, multiplied by the state-determined equalization rate, which converts the total to a market value. Dividing this total by the number of pupils yields $\bar{V}$.

We do not have an ideal measure of V. The ORPS data cover all houses, but most school districts are in several assessing units, which use different assessing methods and are on different assessing cycles (see Eom, 2004).[20] The state equalization procedures are based on a small sample of houses and therefore provide only a partial correction for this variation in assessing practices. The Census measure is more insulated from assessment procedures, but it is available only every ten years.[21] Thus, our measure of median house value is the Census measure updated by the annual percentage change in average residential property value (from ORPS).[22]

Table 2 describes tax-price components and the values of key variables before and after STAR was implemented. The first column indicates that the STAR component of tax price was 68 percent in the average district, which is equivalent to a matching rate of 32 percent, and ranged from 51 percent in the poor upstate large cities to 82 percent in the downstate suburbs.[23] This difference would be even greater were it not for the sales price differential factor. Table 2 also shows that the median voter's tax-share was 36 percent in the average district in 2002.

These variables do not account for renters, who may not care about the level of public services; after all, any improvement in public services may lead to an offsetting increase in rents (Ross and Yinger, 1999).[24] Because STAR does not apply to renters, however, we also investigate the possibility, shown in column two of Table 2, that the appropriate STAR matching rate is zero in majority-renter districts. In our empirical work, we test whether the behavioral response to the STAR matching rate depends on whether a district has a renter majority.

Table 2 also shows that the average property tax rate to support operating spending equaled 1.56 percent before STAR and 1.66 after STAR was implemented, an increase of ((1.66/1.56)) - 1) = 6.12 percent. These are tax rates to cover school operating costs, not overall tax rates. Following equation (2), they are defined as the difference between operating spending and operating aid divided by total property value. Because property values change for many reasons that have nothing to do with STAR, Table 2 also presents an alternative tax rate calculation for 2002 in which the property tax base is held constant in real terms. By this measure, the property tax increased ((1.86/1.56)) - 1) = 19.23 percent over this period. Moreover, real spending per pupil increased ((11,756/10,664)) - 1) = 10.24 percent, and student performance (discussed below) increased ((78.3/74.1)) - 1) = 5.67 percent. Our objective is to determine the extent to which these changes can be attributed to STAR.

In the case of educational outcomes, our approach is to design an index that (1) covers a range of student performance measures, (2) is linked to the types of measures in previous studies and in the New York school accountability system, and (3) is based on variables measured consistently across the years in our panel. This approach leads us to an index that combines fourth grade, eighth grade, and high school test scores and the share of high-school students who have not dropped out by their scheduled graduation date.[25] The test score variables are based on the share of students scoring above a state-determined standard reference point on mathematics and English examinations in each grade. The examinations are central to New York State's accountability system and SED publishes the test results as part of each school's annual report card. Our baseline index gives equal weight to each district's fourth-grade, eighth-grade, and high-school passing rate (the average for math and English in each case), and to the non-dropout rate. We also examine two alternative weighting schemes.

In our study, or any other, the definition of efficiency depends on the performance measures selected. Thus, our efficiency measure and the cost and demand models that include it should be interpreted as illustrative results for one performance index, not as general results that apply regardless of how performance is measured.

Descriptive information on our performance index and other variables is provided in Table 3. All dollar figures are deflated using the CPI.

Cost/Efficiency Model

The dependent variable in equation (10) is spending per pupil. Our regressions use operating spending less transportation.[26] This equation combines cost and efficiency. Because efficiency cannot be measured directly, both our approach and the DEA-based approach require explanatory variables to be classified as cost or efficiency factors. Although a classification scheme cannot be formally tested, the conceptual basis for the scheme used here is grounded in the literature. This scheme is based on the view that cost factors are outside a district's control whereas efficiency factors describe incentives that directly influence the district's behavior.

The link between input prices and costs is, of course, part of the standard theory of the firm. Our salary variable is for teachers with one to five years of experience, holding constant experience and education. Because unobserved school district traits may affect both spending and salaries, this variable is treated as endogenous. An extensive literature, starting with Bradford, Malt, and Oates (1969) develops the argument that educational costs depend on student characteristics. Following the cost studies cited earlier, our variables include the percentage of students eligible for a free or reduced-price lunch, with limited English proficiency, from a single-parent family, or with severe disabilities. In addition, many studies establish a link between educational costs and school district size (Andrews, Duncombe, and Yinger, 2002). Following standard practice, we allow for a U-shaped relationship between size and costs. To control for unobservable factors, our regressions also include county and year dummies plus interactions between county and year.[27]

The literature on the determinants of efficiency is summarized in Duncombe, Miner, and Ruggiero (1997), and hypotheses in this literature are tested in Duncombe and Yinger (1997 1998b, 2001). As expressed in equation (6), efficiency-determinants include the components of augmented income and tax share. Augmented income can be separated into income and aid terms, as in equation (10). Some state aid comes in the form of closed-ended matching aid for transportation and construction, which might affect non-transportation operating spending. We assume that each district has reached the maximum aid amount, so we can specify this aid in lump-sum form. We could not reject the hypothesis that impact of this aid in the cost/efficiency equation (and in the demand equation) was the same as that of standard operating aid. As a result, the all models we present are based on total state aid.[28]

Our regressions include several other efficiency variables. In New York, school districts rely heavily on the property tax. Thus, property value per pupil is a measure of a district's fiscal capacity, and voters in high-property-wealth districts may not be as motivated as voters in other districts to reign in spending that is not devoted to the most basic student performance measures. We also include the share of adults with a college education and the percentage of housing units that are owner-occupied as monitoring variables. More educated voters and homeowners may be more concerned about education quality than other voters, all else equal.

Our estimation treats student performance and teacher salary as endogenous. Instruments for student performance are drawn from nearby districts or districts that have similar enrollment and property values; instruments for teacher salary are drawn from the county labor market.[29] This approach is based on the hypothesis that each district's decisions about performance and salaries are influenced by what is happening in districts that voters and school officials are most likely use as a standard for their own district's performance.

We take several steps to ensure that our instruments are appropriate. First, we rule out any measures of average performance in comparison districts; unobservable factors that influence the behavior a given district might also influence nearby or otherwise similar districts. Instead, we select variables that measure either the exogenous characteristics of comparison districts or the variance in performance of comparison districts. The exogenous characteristics of comparison districts, such as their average poverty rate, influence their performance but are not affected by unobservable factors. Moreover, the variance in the performance of comparison districts influences the clarity of the signal their outcomes send to voters and school officials, again without any link to shared unobservable factors. Second, we put potential instruments through a series of tests to identify the ones that meet the requirements of a valid instrument.[30]

The estimated parameters from equation (10) are used to calculate cost and efficiency indexes for the demand estimation. The cost index, based on equation (11), is scaled to equal 1.0 in the average district. The efficiency index, based on equation (12), is scaled to equal 1.0 in the most efficient district. This efficiency index includes the error terms from the estimated version of equation (10), that is, it assumes that unobserved determinants of spending are associated with efficiency, not with cost. As indicated earlier, nothing is included in our cost index unless it can be explicitly linked to a cost variable outside the control of school officials.

An estimation of equation (10) is presented in column (1) of Table 4. The STAR tax price has a significant impact on efficiency, with an elasticity of 0.307.[31] This result supports the hypothesis that the more STAR lowers a district's tax price, the more inefficient that district becomes.[32] The STAR elasticity is larger than the tax-share elasticity, 0.211, which is also statistically significant. We can reject the hypothesis that these two elasticities are equal, which suggests that the tax-price variation associated with STAR may be more readily perceived by voters than is the variation associated with the composition of the property tax base. Three non-price efficiency variable are also statistical significant, namely, median income, property value per pupil, and total state aid. The estimate flypaper effect, which is the ratio of the aid and income coefficients, is 9.0.

The coefficient of $\ln\{S\}$ is 0.755. Using the coefficient of tax-share to identify δ and the formula in equation (9), we find that $\sigma = 0.689$, which indicates increasing returns to quality scale. We also find that, as expected, costs increase with teacher salaries, with the share of students receiving a free lunch, and with the share of single-parent households. The small coefficient for teacher salaries probably reflects the fact that most salary variation is captured by the county and time dummies. The enrollment variables are also both significant and indicate the same U-shaped relationship between enrollment and cost per pupil found by previous studies.

Column (2) of Table 4 tests the hypothesis that STAR affects voters' valuation of state aid by estimating separate coefficients for the two aid terms in equation (10), namely, $(A/Y)(V/\bar{V})$ and $(A/Y)(V/\bar{V})(X/V)$. The second term isolates the impact of STAR. Both terms are statistically significant with the expected signs, which indicates that STAR does influence voter's valuation of aid. Moreover, we cannot reject the hypothesis that these terms have the same absolute value, so we use the specification in the first column as our base case.

Next, we test the hypothesis that the effective STAR matching rate is zero in majority-renter districts by including an additional variable, namely, $R\,[\ln((1/(1-(X/V)))] = R\,[\ln(V/(V-X))]$, where $R = 1$ in majority-renter districts and zero otherwise. The elasticity of efficiency with respect to the STAR tax-price component in majority-renter districts equals the coefficient of this variable minus the coefficient of the STAR tax-price component in equation (10). A finding that these two coefficients are equal implies that there is no response to the STAR tax price in a majority-renter district, whereas a finding that the coefficient of this new variable equals zero implies that voters in a majority-renter district, like those in majority-owner districts, respond to the STAR tax-price component facing the median homeowner. As shown in column (3) of Table 4, the coefficient of this variable is small and statistically insignificant. We conclude that equation (10) accurately describes the impact of the STAR tax-price component on school district efficiency, even in majority-renter districts. This re-affirms the results in the column (1).

Columns (4) and (5) replicate column (1) using different indexes of student performance. Column (4) removes the non-dropout rate from the index and column (5) removes the high school scores instead. In both cases, the results, including the STAR elasticity, are similar to the results for the basic model in column (1). Thus, our results are not highly sensitive to change in the student performance index, although they obviously might change more substantially if a fundamentally different index were used.

Demand Model

The second part of our analysis is to estimate equation (13) in log form. The dependent variable is the log of our student performance index. The key explanatory variables are the log of augmented income and of tax price. We use the same approximation for the aid term in augmented income that we used in the efficiency equation, and we estimate a separate elasticity for each tax-price component. To account for unobservable factors, we estimate this model with district and year fixed effects.[33] The efficiency index is treated as endogenous. As in the cost equation, instruments are drawn from comparable districts, we rule out as instruments the average values of endogenous variables in comparable districts, and we select our final set of instruments using a series of statistical tests.[34]

Table 5 presents demand results based on cost and efficiency indexes from the model in column (1) of Table 4. The estimated demand coefficients in this case are -0.150, 0.291, -0.041, and -0.053 for the cost, efficiency, tax-share, and STAR components of tax price, respectively. All these coefficients are statistically significant. Using equations (14) and (15), adjusted to allow for differences across tax-price components, we find that the underlying price elasticities for these four components are -0.146, -0.297, -0.042, and -0.054. The last elasticity supports our main hypothesis: STAR boosts the demand for student performance. This effect is not large in magnitude, but it is about the same size as responsiveness to variation in the tax share—and we cannot reject the hypothesis that the two elasticities are equal.

In addition, Column (1) of Table 5 indicates that income has a significant impact on the demand for student performance with a coefficient (elasticity) equal to 0.064 (0.066). The state aid variable has the expected sign, but is not quite significant at the (two-tailed) 5 percent level. The estimated flypaper effect is 2.5, which is much smaller than the flypaper effect in Table 4.

As in the efficiency equation, we test the hypothesis that STAR alters the weight voters place on state aid. As shown in column (2), the second component of the aid variable, which reflects the impact of STAR, has the wrong sign, but is not significant at the 5 percent level. The results in this column also indicate that switching to two aid variables cuts the coefficient of the STAR tax price variable in half and makes it insignificant. These two STAR-related variables are highly correlated (simple correlation = -0.7426), so these results suggest that collinearity prevents us from separating their effects with our data. As a result, we stick with the basic regression in column (1); that is, we assume that voters recognize the impact of STAR on the value of state aid—an assumption supported by the results in Table 4.

Many scholars, including Inman (1978), have argued that the demand for public services may depend on the socioeconomic characteristics of a community. Rockoff (2003) calculates separate STAR tax-price variables for elderly and non-elderly homeowners, on the grounds that elderly homeowners have higher implicit STAR matching rates and might influence district decisions even though they are not the median voter. His elderly tax-price variable is statistically significant in his spending model, but only when elderly homeowners are a small fraction of the population—the opposite of expectations. He concludes that the role of group size is not "well identified." Rockoff also finds that the coefficient of an interaction between the STAR matching rate and the share of public utility property is positive and significant.[35]

Our ability to study these issues is limited; most of our community characteristics do not vary over time because they come from the 2000 U.S. Census, and our district fixed effects remove all cross-sectional variation.[36] Nevertheless, we explore the role of renters using the strategy described earlier for the cost/efficiency equation. The results are presented in column (3) of Table 5. We find, surprisingly, that majority-renter districts are slightly (but not quite significantly) *more* responsive to the STAR component of tax-price than are majority-owner districts. To be specific, the estimated coefficient for the STAR component is -0.042 in majority-owner districts and -0.078 (= -0.042 - 0.036) in majority-renter districts.

Columns (4) and (5) re-estimate the model using the alternative outcome indexes described earlier. As in the case of the cost model, all of the results are similar to those in column (1), although virtually all the coefficients are slightly larger with both alternative indexes.

Column (6) presents results from a demand model that excludes the efficiency index. According to equation (16), when efficiency is excluded the coefficient of income term becomes ($\theta^* - \gamma\mu^*$), and the coefficient of the STAR term becomes $\mu^*(1 - \delta)$. This equation does not quite fit our estimations because it assumes that the flypaper effect is the same in both the cost/efficiency and demand equations and that STAR affects the value of aid to voters in both equations. Nevertheless, we can approximate this equation by imposing these two assumptions and using our estimated parameters. These steps lead us to predict that in a demand equation without efficiency variables the coefficient of the income term will be 0.056 and the coefficient of the tax-share term will be -0.054. We find that the estimated values of these two coefficients without efficiency, -0.001 and -0.005, respectively, in column (6), are indeed smaller in absolute value than those in column (1). This result supports the need to either control for efficiency or else interpret these estimated elasticities with efficiency in mind. The differences between the estimates in columns (1) and (6) is larger, however, that than indicated by the formulas in equation (16). This finding may reflect the assumptions in equation (16), such as the assumption of equal flypaper effects, which is rejected by our regression results.

Full impacts of STAR

Table 6 presents simulated impacts of STAR on student performance, school district efficiency, school spending, and property tax rates. These impacts are based on the results in Tables 4 and 5 combined with data on individual districts and the equations derived earlier.[37] Although the derivatives in equations (17) to (20) provide some helpful initial intuition about these calculations, they are approximations and they make two assumptions not used for Table 6, namely, equal flypaper effects in the cost/efficiency and demand equations and equal elasticities for the various components of tax price.

According to our simulations, STAR actually lowered student performance by 1.07 percent in the average district (column (1)). This result indicates that the positive direct impact of STAR on demand, which is indicated by the demand elasticity for the STAR tax-price component (-0.054), is smaller in absolute value than the negative indirect impact, which equals minus one times the efficiency elasticity for the STAR tax-price component (0.307) multiplied by the demand elasticity for the efficiency tax-price component (0.297). This STAR-induced decrease in *S* leads to a decline in costs, but because of economies to quality scale, the decline in costs, 0.74 percent (column (2)) is smaller than the declined in *S*.

In addition, STAR resulted in a 9.96 percent drop in the efficiency with which the average school district delivers our performance index (column (3)). The total efficiency loss from STAR is $2.08 billion. As explained earlier, this efficiency loss may include waste in the traditional sense, but we suspect that it mainly reflects the fact that the incentives in STAR lead voters to push for spending on objectives other than the ones in our index. In other words, STAR induced school districts in New York State to increase their annual spending on objectives other than boosting math and English scores and keeping student in high school by as much as $2.08 billion. Although these other objectives are valued by voters, the State's expressed interest in these test scores and graduation rates as central elements of its accountability program implies that this is an expensive unintended consequence of STAR. This efficiency cost could be higher or lower, of course, for another set of performance objectives.

These large efficiency decreases resulted in a substantial spending increase, 10.45 percent, in the average district (column (4)). To fund this increase, the average district raised its property tax rate by 26.69 percent. The average pre-STAR property tax rate for operating spending was 1.56 percent (Table 2), so this is equivalent to a rate increase of (1.56)(0.2669) = 0.42 percentage points. In the average district, this tax increase, $\Delta t(V\text{-}X)$, offsets 41.84 percent of the original STAR tax savings, tX, which is an ironic impact for a program designed to reduce property taxes (column (6)). Moreover, this tax increase applies to all property, including property that does not receive a STAR exemption. By raising the property tax rate on business property, STAR may have negative consequences for economic development in New York.

These simulated STAR impacts are similar to the post-pre differences in Table 2, which reflect the impacts of factors other than STAR. Our simulated operating-tax-rate change is similar to the change in Table 2 that holds property value constant in real terms (as do our simulations), namely, 19.23 percent. The simulated impact of STAR on spending is also remarkably close to the actual change in Table 2, namely, 10.24 percent. In contrast, the simulations indicate that STAR lowered student performance, whereas actual student performance increased by 5.67 percent for student performance. Overall, these comparisons strongly suggest that STAR is responsible for most of the tax-rate and spending increases in New York over this period, but that increases in state aid or perhaps in school district efficiency made it possible for districts to boost performance somewhat more and to raise property taxes somewhat less would be expected on the basis of STAR alone.

These simulations assume that property values remain constant in real terms. In fact, however, property values in New York State increased significantly in real terms in most school districts. If the STAR property tax savings were capitalized into house values, some of this increase might be due to STAR. In this case, the simulations in column (5) exaggerate the impact of STAR on effective tax rates. Although estimating the impact of STAR on property values is beyond the scope of this paper, we can calculate the impact of STAR on property tax rates assuming full capitalization.[38] In this context, however, capitalization is a two-edged sword. The capitalization of the STAR exemptions themselves lead to higher property values, but the capitalization of the tax rate increases needed to pay for the STAR-induced spending increases lower property values. Moreover, the second of these effects, unlike the first, applies to all property, not just to single-family homes. As shown in column (7) of Table 6, these two effects roughly offset each other, and, in the average district, the tax-rate increase with full capitalization, 30.79 percent, is virtually the same as the change when capitalization is ignored.

Table 6 also shows that the impacts of STAR were not evenly distributed across the state. Because the tax-price change induced by STAR depends on the median property value and because majority-renter districts respond to STAR as do majority-owner districts, the tax-price impact of STAR are largest in districts with low property values, even if they are cities.[39] Thus, the impacts of STAR are largest in the upstate rural districts, the upstate small cities, and the upstate Big Three districts. These districts experienced relatively large STAR-induced decreases in student performance, but also strikingly high STAR-induced declines in efficiency and increases in tax rate. In contrast, the impacts of STAR are relatively small in New York City.

A comparison of columns (5) and (7) in Table 6 reveals that adding full capitalization magnifies the disparities in STAR's tax-rate impacts. In suburbs, which have little commercial and industrial property, the capitalization of STAR exemptions raises house values and lowers the required tax rate increase. In large cities, however, the concentration of commercial and industrial property implies that the capitalization of STAR-induced tax rate increases for all property dominates the capitalization of the STAR exemptions, and the tax-rate increases in column (7) are larger than those in column (5).

Conclusions and Policy Implications

A state education finance system consists of local property taxes, state-funded property tax exemptions, state aid to education, and sometimes other revenue sources. Each of these components alters both the incentives facing voters and school officials and the distributions of educational outcomes and tax burdens. Proposed changes to any component of this system should be evaluated in terms of its impact on the system as a whole.

When it was passed, the New York's STAR program was thought to be nothing more than a tax-break for local property owners. This paper shows that this perception was not accurate. First, STAR lowers local voters' share of the money that must be raised to pay for additional educational services. By lowering tax share, STAR increased voter's demand for basic elements of student performance, namely English and math test scores and non-dropout rates. In addition, however, STAR appears to have boosted the demand for a broader set of educational outcomes and may have encouraged wasteful spending. As a result, STAR significantly lowered the efficiency with which these basic elements of student performance were delivered. Because efficiency is also part of voters' overall tax price, the direct impact of STAR on the demand for basic student performance was more than offset by an indirect impact that operates through efficiency. The net decrease in basic student performance was about 1 percent in the average district.

The STAR-induced increases in demand and decreases in efficiency resulted in significant increases in school spending and school property tax rates. Ironically, these tax-rate increases offset about 40 percent of the tax savings from the STAR exemptions. Moreover, these efficiency losses and tax-rate increases were particularly large in upstate districts, which include some of the neediest districts in the state. Overall, therefore, STAR has not only increased student performance gaps across the state, but it has also shifted the burden of financing education in an arbitrary and unfair manner. The recent 30 percent increase in the STAR exemptions serves to magnify these effects.

Although the impacts of STAR do not appear to be sensitive to the specific weights in our student performance index, the magnitude of STAR's impacts could be quite different with a fundamentally different measure of school performance. Thus, when evaluating changes in property tax policies or other aspects of the education finance system, state policy makers should specify their performance objectives and make sure that these objectives are not undermined by the unintended consequences of the policies they implement.

The 2006 extensions to STAR add additional variation to the STAR component of tax price. As a result, these extensions may make it possible for future studies with data for 2006-07 to avoid the collinearity that prevented us from estimating the cost/efficiency model with district fixed effects or from separating the price and aid impacts of STAR in the demand model. These extensions also add a new institutional feature, namely, the payment of homestead exemptions in the form of rebate checks instead of lower property tax bills. This feature may make it possible for future studies to determine whether the impacts of STAR on efficiency and demand depend on the institutional mechanism through which the property tax relief is delivered.

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Endnotes

[1] For reviews of this literature, see Rubinfeld (1987), Ladd and Yinger (1991), Duncombe (1996), and Fisher and Papke (2000).

[2] Rockoff (2003) sets district tax price equal to one minus the fraction of local property taxes paid by STAR; this formulation differs from the one derived below.

[3] For more on STAR, see New York State Office of Real Property Services (2004).

[4] Fractional amounts of the exemptions are applied if property owners have any other type of property that they use partially as a primary residence. To receive the basic exemption, all owners of the eligible property must jointly apply on or before the local taxable status date. Once the exemption is granted, the owner need not reapply in subsequent years, unless the exemption is discontinued or revoked by the assessor.

[5] The income limit applies to the combined income of all owners of the property, including the income of any owner's spouses who reside on the premises. The $60,000 income criterion is adjusted annually according to a cost-of-living adjustment (COLA) used by the Social Security Administration. Eligible property owners must reapply every year for the enhanced STAR.

[6] The STAR exemption amount is adjusted for the "big five" cities – New York City (NYC), Buffalo, Rochester, Syracuse, and Yonkers – because these school districts are fiscally dependent on their city and there is no separate school tax rate. In addition, the STAR legislation gives NYC an extra payment (included in state aid) to make up for its high renter share.

[7] The first adjustment simply ensures that the benefits of the STAR exemptions do not depend on assessing practices. The second adjustment provides an extra benefit to wealthy counties and is not supported by any public finance principle we know of. See Duncombe and Yinger (1998a). The "sales price differential factor" cannot fall below 1.0, so it provides higher exemptions in the

high-housing-value districts but does not change exemptions elsewhere. All districts in downstate counties have a sales price differential factor greater than one

[8] The adjustment for assessing practices is not relevant here because our model is already based on market values, not assessed values.

[9] For a review of the literature on the flypaper effect, see Hines and Thaler (1995); for a recent contribution, see Roemer and Silvestre (2002).

[10] We exclude the efficiency component of tax price from the efficiency equation. It makes no sense to argue that voters will monitor school officials more actively when a low level of monitoring leads to inefficiency!

[11] This assumption is not critical for our conclusions. The simulated impacts of STAR would be roughly the same as those presented below if we set the elasticity of e with respect to MC equal to zero or if we set it equal to twice the estimated elasticity of e with respect to $V/\overline{V}$.

[12] Ruggiero (1996) shows how to develop a DEA measure that directly removes the impact of cost factors. We have not used this clever approach because it requires a very large data set.

[13] DEA uses linear programming to determine a "best-practice frontier" for production. It was developed by Farrell (1957), Charnes, Cooper and Rhodes (1978), and Fare and Lovell (1978). Strengths and weaknesses of DEA are discussed in Seiford and Thrall (1990) and Ruggiero (1996). DEA is popular for evaluating productive efficiency in the public sector because it handles multiple outputs, is nonparametric, and can be applied to both production and cost.

[14] Using DEA with the components of our education performance index would result in an inconsistency between the weights in our index and the implicit weights estimated through DEA.

[15] This step also adds 1 to the exponent of the C^* (= MC) term.

[16] These assumptions about these three parameters might hold with the unspecified broad school performance measure in the demand interpretation even if they do not hold with the specific measure in the cost interpretation, but there is no way to determine whether or not this is true.

[17] These derivatives are evaluated at $m = 0$ (which corresponds to a starting point without STAR), with $dm = X/V$ (which corresponds to implementing STAR), and with $\sigma = 1$.

[18] Without constant returns, the coefficients in the numerators become $[(\theta^* - \gamma\mu^*)(\sigma(1 - \delta) + \delta) - \gamma]$ (first term) and $[\mu^*(1 - \delta)(\sigma(1 - \delta) + \delta) - \delta]$ (second term).

[19] Without constant returns, the coefficient in the numerator become $[\gamma + \theta^*(\sigma\text{-}1)\delta]$ (first term) and $[\delta + \mu^*(\sigma\text{-}1)\delta]$ (second term).

[20] Outside cities, assessing units are usually towns (subsets of counties), which are not coterminous with school districts. New York State has 993 city and town assessing units, two county assessing units, and dozens of small village assessing units. See Eom (2004).

[21] Another disadvantage of the Census measure is that it cannot be corrected for the few non-STAR exemptions; this is a minor disadvantage, however, because these specialized exemptions (e.g. for veterans) probably do not apply to the median house.

[22] We also explored models using measures of V based on ORPS data only and on Census data only. The results are similar to those presented in the text.

[23] For both measures, the simple correlation between the ORPS-based measure and our preferred Census measure is over 0.9.

[24] This view is supported by evidence that renters are less likely to vote (see DiPasquale and Glaeser, 1999).

[25] We do not have a consistent measure of the graduation rate, so we use one minus "the rate of dropouts, which refers to any student, regardless of age, who left school prior to graduation for

any reason except death and did not enter another school or high school equivalency preparation program or other diploma program" (New York State Department of Education, 2003). Our panel includes only one pre-basic-STAR year because the state used 3rd and 6th grade tests instead of 4th and 8th grade tests in the year before our panel begins.

[26] We remove transportation spending because it is not directly related to student performance and involves a unique set of cost factors, such as district area and population density.

[27] Including district fixed effects (DFE) would provide an even stronger control for unobserved time-invariant factors. In fact, however, county and time dummies already explain over 80 percent of the variation in our STAR tax price-variable. DFE and time dummies explain even more of this variation, 97.7 percent, and the coefficient of this variable cannot be estimated with precision when DFE are included. Moreover, the inclusion of DFE also lowers the precision of the cost and efficiency variables. Results with DFE are available from the authors upon request.

[28] Regressions with a separate transportation/building aid variable and/or with distinctions among various types of standard operating aid are available from the authors. These alternative specifications do not alter any of our substantive conclusions about the impacts of STAR. Moreover, the transportation/building aid variable always has a significant impact on operating spending or on student performance and we generally cannot reject the hypothesis that this aid has the same coefficient as operating aid.

[29] To be specific, we define 17 enrollment/property-value classes, one of which consists of the five large city districts in the state.

[30] We conducted three types of tests for the instruments in the cost model (and the demand model, which is discussed below). First, we regressed each endogenous variable against various combinations of the instruments to identify groups of instruments that have a significant

impact—the first requirement for a good instrument. We rejected any potential instrument that was not significant at the 10 percent level for at least one endogenous variable. Second, we checked the correlation between each instrument that passed the first test and the dependent variable by including each instrument, one at a time, in a preliminary 2SLS version of the cost model (using all the other instruments). We kept only those potential instruments that are not significant in the cost model (as indicated by a t-statistic below 1.0), which is the second requirement for a good instrument. Third, we conducted an over-identification test (Wooldridge, 2003) on the remaining instruments to determine if they instruments are indeed exogenous. The selected instruments are all significant in the first-stage regression at the 1 percent level and not significant in the second-stage regression at the 10 percent significance level. The high first-stage t-statistics mitigate concerns about weak instruments (Bound, Jaeger, and Baker, 1995). The final set of instruments is the county manufacturing wage, the county construction wage, the range of 8th grade test scores of adjacent districts, the maximum 4th grade test scores in the same district class, the standard deviation of 4th grade English test scores in the same class, and the class average percent of students receiving a free lunch.

[31] Recall from equation (19) that the sign of the efficiency elasticity for variable *X* is the opposite of the sign of *X*'s estimated coefficient.

[32] Our approach is to model the tax exemption for which voters are eligible, not the exemptions voters actually claim. Because not all voters apply for their STAR exemptions, these two approaches might not lead to the same answer. However, STAR has been widely publicized, and we see no reason to think that the median voter does not know about and apply for a STAR exemption. Rockoff (2003) provides some evidence that is consistent with this position:

STAR's estimated impact on spending is about the same whether STAR exemptions are defined by entitlement or by a rough estimate of actual claims (with entitlement as an instrument).

[33] Hausman tests support fixed effects over random effects. District and time fixed effects co not rule out the possibility of bias due to district-specific, time-varying unobserved factors. In fact, however, federal and state education policies, which are the most likely source of this type of variation, were quite stable in New York during our sample period. School report cards; the state accountability system, which places the lowest-performing schools "under registration review"; and tests as high-school graduation requirements all were implemented before 1998-99. The only shift to a more rigorous test during our sample period was the one in science in 1999-2000. See New York State Education Department (2003). Moreover, NCLB was passed in 2002 and implemented in 2002-2003. Bias from time-varying unobservables is even less likely in our cost equation, which includes interactions between county and year fixed effects.

[34] Our instrument tests are described in footnote 30. The final set of instruments for the demand equation is the maximum per pupil personal income in the same district class, the class maximum efficiency index, and the standard deviation of the efficiency index for the same class.

[35] We do not find this result compelling, however, because Rockoff also omits the tax-share term, $V/\overline{V}$, which plays a central role in demand theory and which is obviously correlated with the share of non-residential property.

[36] Rockoff faces similar data limitations but goes to great effort to estimate elderly and non-elderly house values using the 2000 5-percent Census IPUMS data and other sources.

[37] We calculate the impact of STAR using equations (2), (5), and (6)-(8), with separate coefficients for each tax-price term and with separate flypaper effects for the efficiency and demand equations. These equations are used to derive the percentage changes in S, C, e, E, and t

when the STAR matching rate goes from zero to *X/V*. These equations are then combined with our estimates of the parameters and data from school districts in the state to obtain the results in Table 6. A technical appendix containing these equations is available from the authors.

[38] Our equations for the full-capitalization case are available in a technical appendix. STAR-induced increases in *S* also might be capitalized into house values, and higher-property values reduce *e* (see Table 4) and thereby raise *E* and *t*, all else equal. These two effects are not included in our full-capitalization calculations both because they are small in magnitude and because, roughly speaking, they offset each other. The literature on tax and service capitalization is reviewed in Ross and Yinger (1999).

[39] Our simulations ignore the hard-to-interpret (and not-quite-significant) result in Table 5 that majority-renter districts are actually somewhat more responsive to STAR; the STAR-induced disparities would be even greater with out this assumption.

Table 1. STAR Savings

Region	STAR Savings[a] (per pupil)	STAR Exemptions[b] (% of value)
New York City	$320	3.61%
Yonkers	$1,289	15.91%
Downstate Small Cities	$1,290	7.64%
Downstate Suburbs	$1,395	9.54%
Upstate Big Three	$564	15.11%
Upstate Small Cities	$916	13.06%
Upstate Suburbs	$1,048	14.82%
Upstate Rural	$816	13.48%
Average District	$1,055	12.91%

[a]2001-2002 property tax reduction per pupil due to STAR exemptions.

[b]For 2001-2002; includes both enhanced and basic STAR exemptions; as a percentage of total property value.

Table 2. Features of STAR and School District Outcomes

Region	STAR Tax-Price Component: Basic	STAR Tax-Price Component: With Renter Adjustment	Tax Share	Pre-STAR: 1998-99 Effective Tax Rate[a]	Pre-STAR: 1998-99 Spending Per Pupil ($2002)	Pre-STAR: 1998-99 Performance Index[b]	Post-STAR: 2001-2002 Effective Tax Rate	Post-STAR: 2001-2002 Alternative Effective Tax Rate[c]	Post-STAR: 2001-2002 Spending Per Pupil	Post-STAR: 2001-2002 Performance Index[b]
New York City	79.81%	100.00%	63.03%	1.09%	$9,599	52.7	1.08%	1.28%	$11,284	58.6
Yonkers	70.00%	100.00%	56.04%	0.88%	$12,783	53.5	1.07%	1.15%	$14,206	59.0
Downstate Small Cities	76.65%	90.97%	43.10%	1.40%	$13,878	69.8	1.60%	1.61%	$14,682	77.5
Downstate Suburbs	81.76%	82.24%	38.09%	1.76%	$14,095	78.8	1.37%	2.03%	$14,977	84.6
Upstate Big Three	51.36%	100.00%	46.48%	1.47%	$10,308	51.2	1.89%	1.69%	$11,557	53.8
Upstate Small Cities	59.41%	68.86%	37.22%	1.51%	$9,686	67.8	1.75%	1.82%	$11,392	71.1
Upstate Suburbs	67.29%	67.82%	36.96%	1.57%	$9,334	75.1	1.80%	1.82%	$10,199	78.8
Upstate Rural	57.85%	57.85%	30.85%	1.40%	$9,702	71.9	1.71%	1.80%	$10,998	75.7
Average District	67.51%	68.92%	36.00%	1.56%	$10,664	74.1	1.66%	1.86%	$11,756	78.3

[a] This rate equals (operating spending minus operating aid)/(total property value).

[b] The performance index places equal weight on proficiency rates in English and math in (1) 4th grade, (2) 8th grade, and (3) high school and on (4) the non-dropout rate.

[c] This rate equals (2002 operating spending minus 2002 operating aid)/(1999 total property value inflated to 2002 dollars)

Table 3. Descriptive Statistics, 615 New York School Districts, 1999-2002

Variable	Mean	Std. Dev.	Min	Max
Log of per pupil operating expenditure[a]	9.253	0.214	8.432	10.844
Log of performance index (equal weights for 4 measures)[b]	4.331	0.112	3.785	4.589
Log of performance index (alternative weights)[c]	4.230	0.166	3.265	4.583
Log of performance index (alternative weights)[d]	4.353	0.104	3.847	4.601
Log of teacher salary[a d]	10.356	0.361	5.899	10.825
Log of enrollment	7.496	0.945	4.575	13.872
Percent of students with limited Eng. proficiency (LEP)	1.283	3.040	0.000	27.128
Percent of children receiving free lunch	22.241	15.464	0.000	90.842
Percent of children with female household head	13.647	5.193	5.049	43.140
Percent of high cost students	1.139	0.893	0.000	6.299
Log of median family income[a]	10.754	0.696	9.681	37.511
Per pupil property value[a]	361,994	464,597	61,053	10,500,000
Log of general tax share	-0.965	0.456	-3.462	2.148
Log of STAR tax price	-0.201	0.198	-1.396	0.000
Log of efficiency index	4.073	0.155	2.553	4.605
Log of cost index	4.601	0.184	4.097	5.729
Ratio of state aid to median income	0.039	0.030	0.001	0.553
Percent of adults with college education[f]	0.032	8.097	-28.975	33.540

[a] Adjusted for inflation using the CPI

[b] The performance index places equal weight on proficiency rates in English and math in (1) 4th grade, (2) 8th grade, and (3) high school and on (4) the non-dropout rate.

[c] Weights equal 33.3% for 4th grade scores, 8th grade scores, and the non-dropout rate.

[d] Weights equal 33.3% for 4th grade scores, 8th grade scores and high school scores.

[e] Predicted salary of teachers with less than 5 years experience.

[f] Residuals of regression of education level on median income.

Sources: New York State Department of Education, National Center for Education Statistics, New York State Comptroller's Office, New York State Office of Real Property Tax Service, and U.S. Census Bureau.

Table 4: Cost/Efficiency Model[a]

Variable	Basic Model[a]	Test of STAR's Aid Impact	Test of Renters' Role	Basic Model with Alternative Outcome Index 1[b]	Basic Model with Alternative Outcome Index 2[c]
	(1)	(2)	(3)	(4)	(5)
Cost Variables					
Log of performance index	0.755	0.745	0.765	0.532	0.602
	[2.10]*	[2.12]*	[2.27]*	[2.22]*	[2.00]*
Log of teacher salary	0.058	0.059	0.058	0.058	0.061
	[3.69]**	[3.65]**	[3.71]**	[3.64]**	[3.98]**
Log of enrollment	-0.339	-0.351	-0.337	-0.36	-0.326
	[7.25]**	[7.43]**	[7.05]**	[6.96]**	[7.69]**
Square of log enrollment	0.019	0.02	0.019	0.021	0.018
	[6.25]**	[6.41]**	[6.09]**	[6.05]**	[6.60]**
Percent of students with limited Eng	-0.002	-0.002	-0.002	-0.002	-0.002
	[1.49]	[1.56]	[1.48]	[1.51]	[1.24]
Percent of children receiving free lunch	0.006	0.006	0.006	0.006	0.005
	[5.01]**	[5.14]**	[5.36]**	[5.11]**	[5.90]**
Percent of household with female head	0.004	0.004	0.004	0.005	0.004
	[3.22]**	[3.19]**	[3.16]**	[3.31]**	[3.23]**
Percent high cost students	0.005	0.005	0.005	0.004	0.004
	[1.61]	[1.77]	[1.62]	[1.38]	[1.32]
Efficiency Variables					
Log of median income	0.236	0.223	0.236	0.242	0.246
	[4.16]**	[3.89]**	[4.20]**	[4.43]**	[4.47]**
Per pupil property value	8.32E-08	8.37E-08	8.32E-08	8.25E-08	8.38E-08
	[8.68]**	[8.29]**	[8.65]**	[8.57]**	[8.03]**
Log of tax share	-0.211	-0.196	-0.211	-0.21	-0.207
	[7.39]**	[6.58]**	[7.39]**	[7.30]**	[7.63]**
Log of STAR tax price	**-0.307**	**-0.274**	**-0.307**	**-0.296**	**-0.292**
	[5.56]**	**[3.63]****	**[5.49]****	**[5.38]****	**[5.91]****
Percent of adults with college education	0.001	0	0.001	0.001	0.001
	[0.62]	[0.45]	[0.62]	[0.74]	[1.01]
Total state aid variable	2.133		2.138	2.177	2.031
	[4.09]**		[4.09]**	[4.01]**	[4.36]**
Total aid, part I		1.7			
		[3.66]**			
Total aid, part II		-1.834			
		[2.37]*			

Table 4: Cost/Efficiency Model[a] (Continued)

Variable	Basic Model[a]	Test of STAR's Aid Impact	Test of Renters' Role	Basic Model with Alternative Outcome Index 1[b]	Basic Model with Alternative Outcome Index 2[c]
	(1)	(2)	(3)	(4)	(5)
Renter Interaction for STAR tax price			0.018		
			[0.37]		
Constant	8.452	4.577	20.026	10.119	-1.22
	[0.34]	[0.18]	[0.96]	[0.39]	[0.05]
Observations	2460	2460	2460	2460	2460
Number of School Districts	615	615	615	615	615

Notes: Operating spending (less transportation) per pupil is the dependent variable; estimated with two- stage least squares (the performance index and teacher salaries are endogenous); county and year fixed effects (and the interactions between them) are also included. As discussed in the text, instruments are county wage variables and values of related variables for neighboring districts and districts in the same wealth-enrollment class. Data cover 1998-99 through 2001-2002.

[a] Weights equal 25% for 4th grade scores, 8th grade scores, high school scores, and the non-dropout rate

[b] Weights equal 33.3% for 4th grade scores, 8th grade scores and high school scores and zero for the non-dropout rate.

[c] Weights equal 33.3% for 4th grade scores, 8th grade scores and the non-dropout rate and zero for high school scores.

"Numbers in brackets are t-statistics; a * (**) indicates significance at the two-tailed 5 (1) percent significance level."

Table 5. Demand Model[a]

Variable	Basic Model[a]	Test of STAR's Aid Impact	Test of Renters' Role	Basic Model with Alternative Outcome Index1[b]	Basic Model with Alternative Outcome Index2[c]	Basic Model without Efficiency
	(1)	(2)	(3)	(4)	(5)	(6)
Log of median family income	0.064	0.063	0.064	0.099	0.066	-0.001
	[2.81]**	[2.79]**	[2.80]**	[2.97]**	[2.48]*	[0.12]
Log of cost index	-0.15	-0.146	-0.147	-0.227	-0.125	0.027
	[2.56]*	[2.48]*	[2.51]*	[2.64]**	[1.81]	[1.15]
Log of predicted efficiency	0.291	0.29	0.289	0.436	0.294	
	[3.21]**	[3.20]**	[3.19]**	[3.31]**	[2.77]**	
Log of tax share	-0.041	-0.042	-0.042	-0.058	-0.042	-0.005
	[3.09]**	[3.24]**	[3.19]**	[2.89]**	[2.75]**	[0.56]
Log of STAR tax price	**-0.053**	**-0.024**	**-0.052**	**-0.076**	**-0.061**	**-0.008**
	[3.19]**	**[1.26]**	**[3.15]****	**[3.29]****	**[3.11]****	**[0.76]**
Total state aid variable	0.16		0.173	0.19	0.19	0.064
	[1.91]		[2.07]*	[1.50]	[2.03]*	[0.69]
Total aid, part I		0.049				
		[0.68]				
Total aid, part II		0.289				
		[1.65]				
Renter interaction for STAR tax price			0.036			
			[1.89]			
Constant	3.041	3.041	3.037	2.286	2.944	4.182
	[7.94]**	[7.98]**	[7.93]**	[4.13]**	[6.68]**	[24.63]**

Table 5. Demand Model[a] (Continued)

Variable	Basic Model[a]	Test of STAR's Aid Impact	Test of Renters' Role	Basic Model with Alternative Outcome Index1[b]	Basic Model with Alternative Outcome Index2[c]	Basic Model without Efficiency
	(1)	(2)	(3)	(4)	(5)	(6)
Observations	2460	2460	2460	2460	2460	2460
Number of school districts	615	615	615	615	615	615

Notes: The dependent variable is an index of proficiency rates on 4th grade, 8th grade, and high school exams in English and math and the non-dropout rate; the cost and efficiency variables are based on the regression in column (1) of Table 4; estimated with two-stage least squares (with the efficiency variable endogenous); estimated with district and year fixed effects. As discussed in the text, instruments are values of related variables for neighboring districts and in the same wealth-enrollment class. Data cover 1998-99 through 2001-2002.

[a] Weights equal 25% for 4th grade scores, 8th grade scores, high school scores, and the non-dropout rates.

[b] Weights equal 33.3% for 4th grade scores, 8th grade scores, and high school scores and zero for the non-dropout rate.

[c] Weights equal 33.3% for 4th grade scores, 8th grade scores and the non-dropout rates and zero for high school scores.

"Numbers in brackets are t-statistics; a * (**) indicates significance at the two-tailed 5 (1) percent significance level."

Table 6. Simulated Impacts of STAR on School Districts in New York State

	Estimated Percentage Impact of STAR on						
Region	Student Performance Index (1)	Total Education Costs (2)	School District Efficiency (3)	School Spending Per Pupil (4)	School Property Tax Rate (5)	Offset of STAR Savings (6)	Tax Rate with Full Capitalization[a] (7)
New York City	-0.46%	-0.32%	-5.03%	4.96%	8.38%	29.82%	11.46%
Yonkers	-0.69%	-0.47%	-7.59%	7.70%	17.90%	36.55%	21.91%
Downstate Small Cities	-0.79%	-0.54%	-7.38%	7.49%	12.10%	30.74%	11.63%
Downstate Suburbs	-0.72%	-0.50%	-6.18%	6.09%	8.14%	29.92%	5.80%
Upstate Big Three	-1.03%	-0.71%	-11.38%	12.04%	33.31%	36.17%	49.97%
Upstate Small Cities	-1.18%	-0.82%	-11.58%	12.31%	27.17%	34.86%	36.20%
Upstate Suburbs	-1.03%	-0.71%	-9.68%	10.01%	19.45%	34.57%	19.05%
Upstate Rural	-1.40%	-0.96%	-13.05%	14.14%	50.84%	62.57%	64.36%
Total	-1.07%	-0.74%	-9.96%	10.45%	26.69%	41.84%	30.79%

Notes: These simulations are based on the estimated coefficients in Tables 4 and 5 and on the formulas in the text, adjusted to allow for different flypaper effects in the cost/efficiency and demand regressions and to allow for different price elasticities for the different tax-price components.

[a] This column assumes that the STAR exemptions and STAR-induced property tax rate increases are fully capitalized into house values and (for the rate increase only) into the value of commercial and industrial property.